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September 8, 1999

Ms. Magalie Roman Salas, Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Dear Madam Secretary,

Enclosed please find one original plus four copies of comments in the Commission's Notice of Proposed Rulemaking MM Docket 93-177, RM-7594. Questions regarding this submission may be directed to the undersigned.

Sincerely,

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List ABCDE

Before the
Federal Communications Commission
Washington, D.C. 20554

In The Matter of	)	
	)	
An Inquiry Into the Commission's	)	
Policies and Rules Regarding AM	)	MM Docket # 93-177
Radio Service Directional Antenna	)	RM-7594
Performance Verification	)	

Comments of **Thomas G. Osenkowsky**

The Commission has initiated a Notice of Proposed Rulemaking pertaining to its rules governing AM directional antenna performance verification. Many of the rules governing AM directional antennas have ben in place for over one half century. Since the inception of directional antennas, many technological advances have been made yet the Commission's rules have remained virtually unchanged.

One of the main tools employed to verify the adjustment of a directional antenna system is the proof-of-performance. The proof-of-performance process involves making a number of field intensity measurements at prescribed intervals along specific azimuth radials centered about an array of antennas. This process suffers from several inherent flaws. First, field intensity measurements are subject to environmental and climactic changes. For a practical example, in October, 1992 I was hired by a 50 kw non-directional New York City AM station to perform field intensity measurements to allow the station to determine the Inverse Distance Field (IDF) on eight radials. Measurements were taken at various distances ranging from 0.8 to 4.0 km. Monitor points were selected by using the following criteria:

1. The location had to be free of obstacles such as overhead power lines, directly over storm drains, and in a fairly open area.

2. The location had to appear permanent and accessible i.e. not in a construction lot or highway intersection.

3. The measured field intensity should display at least a 20 db maximum to minimum signal ratio. This was to reasonably assure freedom from reradiation.

Even using the above criteria, it was easily possible to move 10 meters on the radial and observe field intensity variations of ±50%. This is the equivalent of a four-fold power change. If this were a directional station, the above measurements would be employed to determine the IDF of the radial, upon which the adjustment of the array would be based.

In another example, a directional (DA-2) station in the Waterbury, Connecticut area was inspected by the Commission on March 17, 1993. On this date, there remained six inches of snow on the ground and it was raining steadily. The inspector noted the following discrepancies with three of six night mode monitor points:

Radial	**Measured F.I.**	**Maximum Authorized F.I.**
15°	24.0 mv/m	19.9 mv/m
228°	6.0 mv/m	3.5 mv/m
298°	5.0 mv/m	3.6 mv/m

A Notice of Violation was issued against the station. The antenna monitor values were well within tolerance for both daytime and nighttime patterns. I was retained by the station owner to resolve the issue of license non-compliance. On April 13, 1993 I measured the above monitor points with results tabulated below:

Radial	**Measured F.I.**
15°	19.5 mv/m
228°	2.55 mv/m
298°	1.7 mv/m

It is interesting to note the 228° and 298° field intensity variation. On April 13, 1993 the antenna monitor parameters were virtually identical to those noted on March 17, 1993. The variation in measured field was due solely to climactic and environmental change.

It is a long established practice to perform field intensity measurements during summer months for the purpose of demonstrating (lower than M301) conductivity in AM power increase or new station applications. In the New England region of the United States conductivity can range below 0.1 ms. It is not at all uncommon to record field variations of over ±50% for a non-directional radiator given constant power over various seasons and ground conditions.

In a third actual example, I conducted a full proof-of-performance for a station in central Connecticut in 1996. This station added a night pattern (DA-2) with a power level of 80 watts. The daytime power is 2.5 kw. A sub-contractor provided a set of field measurements per specifications he received from my office. Upon analyzing the data, it was apparent that the RMS of the night pattern reflected a power level of approximately 170 watts. It was necessary to perform additional close-in measurements on a number of radials to demonstrate a ND IDF which was in closer agreement with nearby daytime radial IDF's and conductivities. In effect, we were choosing data points to match a curve whereas the practice is usually the reverse.

At this same station in the fall of 1988 two self-supporting towers were erected to replace two guyed towers. The purpose of this project was twofold. First, the self-supporting towers would allow the array to be located wholly on the station property, alleviating a lease with a neighbor. Second, the daytime power was increased from 500 watts to 2500 watts. A full proof-of-performance was conducted during the latter months of 1988. At that time, the undersigned supervised the measurement project. A great number of close-in measurements were made. Development and construction were very much in evidence at that time. The great number of measurements were made with the knowledge that many of the measurement locations would be obliterated in a short span of time. It was hoped that a sufficient number of points could be retained for future use. In 1996 it was realized that these hopes had faded and a new proof-of-performance project had to be undertaken.

The above examples are provided to demonstrate that field intensity measurements do not always reflect actual operating conditions. Often times, measured field data is chosen to meet the needs of filing data with the Commission. An obvious example is where no exact description of measuring locations is retained i.e. when doing a partial proof. At best one has the reduced topographic maps which were part of the latest full proof-of-performance. Having only this data, the engineer performing the measurements has some freedom of exact measuring location. Again, the data is chosen to match a curve which is not exactly scientific. One must also realize that the proof-of-performance process makes the radical assumption that radiation at vertical elevation angles will fall within specifications based on a horizontal series of measurements and calculated IDF's.

As the Commission realizes, there are a number of computer programs available to the public which may be used to accurately model antennas. A computer program is simply a tool. Regardless of mathematical complexity, the program is a tool which must be used properly. The use of "moment method" analysis is extremely useful for feeder system design. A long standing problem with matching network design has been the accurate determination of tower base operating impedance, drive current magnitude and phase relationship. The design formulae contained in the Commission's rules makes the assumption that the current distribution on all elements in a directional array is sinusoidal and the phase angle is constant throughout the height of the radiator. These assumptions are usually always incorrect.

As an actual example, I will use the theoretical parameters for the Waterbury, Connecticut area AM station previously referenced above. The frequency is 1380 Khz. Day power is 5 kw, night is 0.5 kw.

Twr	Day Phase	Day Ratio	Night Phase	Night Ratio	Spacing	Orientation	G
1	-142.5°	0.437	+167.2	0.584	72.2°	340.0°	126.2°
2	-3.0	1.000	-8.0°	1.000	17.5°	250.0°	115.0°
3	+142.5	0.553	-167.2°	0.684	72.2°	160.0°	126.2°

As a matter of interest, I will list the calculated $_1$ current and phase distribution for tower #1 in both day and night modes:

Height Above Base	Day Phase	Day Current	Night Phase	Night Current
0.0	+157.5°	0.675 A	+174.9°	1.31A
10.8° (6.52 m)	-159.4°	2.13 A	+173.1°	2.0 A
21.7° (13.1 m)	-154.2°	3.12 A	+172.5°	2.41 A

It is evident that the phase and magnitude variation is considerable in the day pattern near the tower base. Sampling at this location is undesirable. As a matter of interest, the calculated base operating impedance in the day mode is -2016+j1220Ω. For the night mode, the base operating impedance is a more reasonable 43.4+j506Ω. Prior to a phasor redesign and rebuild by this writer in 1992, the tower #1 ATU input impedance measured 0+j100Ω with a Delta OIB-3 Operating Impedance Bridge. With the aid of moment method based computer tools [1] and presetting all coil taps to newly calculated values, the input impedance on tower #1 in the day mode measured 52+j12Ω. The calculated base parameters were all within FCC limits. The monitor point limits were not exceeded on either pattern. Unfortunately, in this array the rigid sample loops are located approximately 20 feet above each tower base. The sole advantage here is the lack of need for sample line isolation coils. The computer analysis was used as an aid in the redesign of the phasing and feeder system. Each tower's self impedance was measured as was the mutual impedance of each pair of towers. These values assisted in choosing the proper physical characteristics upon which the program produced its answers.

There exists variation in the kernel of the moment method analysis method. Most engineers are familiar with the *Mininec* series of computer programs [2]. While this series of programs has been successfully employed by many engineers, the code was not written in terms familiar to broadcast engineers i.e. field ratio, phase angle, spacing, orientation, etc. Moment method programs depend on radiator physical definitions in terms of wires. Each wire has a specific x,y physical coordinate. Each wire may have one or two connections. This convention permits modeling of a vast number of structures. Most moment method programs require the electrical drive values to be entered in terms of magnitude and phase angle. In fact, most engineers wish to solve for these values. In nearly all cases we know the values of field ratio and phase angle, not the value of base drive parameters necessary to produce these fields from each radiator.

Some engineers have written matrix routine to be able to solve these unknowns. At least one program [1] allows conventional field parameters to be entered directly. For towers of uniform construction, the experience of this writer has been that the values sampled at the current loop bear close resemblance to calculated values. Some engineers have reported inaccuracies when using moment method based computer models. Some of this experience may have resulted from the differences in the kernel of the computer code or ground model. Generally speaking, many moment codes can produce remarkably accurate solutions when vertical uniform guyed towers are modeled as 'fat' wires with heights and widths adjusted to produce self impedances which correlate well with measured values. This method was employed in the DA-2 example cited above. The results of the use of the moment method code plus circuit analysis program [3] yielded exceptional performance especially when compared to the previous adjustment. One problem with a proof on this array is a westerly radial where three monitor points on this radial measure constant field values regardless of meter position or orientation. One immediately believes that the FIM is set to the battery monitor position. This negates three of ten measuring locations which fall with the present FCC guidelines for partial proof measurements.

Ideally, it would be advantageous if one moment method computer program were adopted by the Commission such as the RADIAT program is employed now. All submissions are analyzed by this program to ensure compliance with allocation restrictions. While the differences between various NEC codes are well beyond the scope of these comments, it is believed that one can assure proper array adjustment if the Commission were to allow use of such computer codes provided the following specifications are adhered to:

1. All sampling lines are of equal measured electrical length. Length can be measured using an inexpensive RF oscillator, frequency counter and oscilloscope.

2. Identical, rigid sampling loops are located at the current loop for tall towers or identical sampling toroidal transformers are employed for short towers.

3. All calculations are clearly shown in the Form 302 submission along with measurements and procedures for determining sample line length. This would also aid in future troubleshooting.

If field intensity measurements are employed for any reason, consideration should be given to freedom of choice for distance used in calculation of Inverse Distance Field (IDF). Presently, an arbitrary value of one kilometer (previously one mile) is used. Frequently, minor structures can cause minimal reradiation which upsets the close in value of IDF. In many instances extensive a detuning program is undertaken which creates an array of parasitic elements. In one such case in Connecticut a two tower array located near railroad tracks was found not able to be adjusted within specification without detuning a series of ten railroad power towers, a nearby smokestack and a nearby nondirectional broadcast tower. While these structures may have contributed to a distortion in the measured field within several miles of the array, measurements in the farther field proved within limits. Since we employ a close in IDF value to determine array adjustment, considerable expense must be borne by a licensee to install and maintain detuning apparatus on structures which in the majority of cases are not directly under his control or access.

The Commission proposes to lessen the number of measuring points on radials that may be employed in a proof-of-performance. This writer agrees with that proposal. The Commission still prefers to employ close-in measurements for IDF determination. I believe that a simpler assumption of power ratio may also be suitable where access to such points is difficult or impossible. For example, if a ND mode is engaged at a power of 1 kw, and a null radial is designed to radiate only 250 watts in a given direction a measured field (voltage) ratio of 2:1 may be employed. In the case of the three tower Connecticut station cited above, what was once open land around the array has now taken the form of condominium complexes surrounding the site. A nondirectional proof which conforms to the Commission's specifications would be nearly impossible without taking measurements within the confines of people's homes. This is also no doubt the case in many other areas.

The Commission seeks comment on the value and validity of permanent monitor points. These points, in writer's experience, seldom reflect the true operating condition of an array. While there is merit in measuring a DA:ND ratio, few arrays are equipped to operate in the ND mode at the push of a button. Once again, in the Connecticut station cited above, ND measurements were performed while energizing the center tower with the end two towers floated. Given the height of these towers, the resultant ND pattern was oval as opposed to round shaped when plotted on a polar graph. No relay system is employed to operate this array in nondirectional mode. Additionally, one must account for the impedance (mis)match between modes i.e. self vs operating impedance. For these reasons as well as the well documented seasonal variation effects, this writer believes that the practice of establishment of permanent monitor points should be abolished in favor of well constructed, documented and maintained sampling systems.

The Commission believes that base current metering should be abolished. This writer wholeheartedly agrees. Base ammeters are subjected to harsh environments and especially in the case of tall towers, yield little insight into determining if an array is operating properly.

It has long been required to submit base or common point impedance data across a range of frequencies. This writer believes these measurements yield no value to the Commission. It is also inconvenient to perform these measurements since the station must cease broadcasting while the measurements are performed. An operating impedance bridge can be inserted even while a station is broadcasting to measure carrier impedance in the 'hot' mode. This writer believes only carrier impedance has value in determining operating power by the direct method. This writer also believes that such measured value should only be kept on file at the station and no longer need be submitted to the Commission. This would greatly reduce paperwork for licensees as well as the FCC. Many times ND base impedance can change due to the addition of an isocoupler, etc. Remeasured values can be maintained in the station log or records. Sideband impedance rotation is most important at the PA final amplifier stage in a transmitter, not at the common point, ATU input or transmitter antenna terminals. This writer has presented numerous papers on this subject. Common point reactance is of little value to the Commission as it does not affect direct power determination. At times some reactance is left at the CP location to make up for phasor hardware etc.

The Commission seeks comment on so-called critical arrays. This writer agrees with the proposal to limit calculations to directions pertinent to the petitioning party. The number of mathematical permutations with one tower selected as a reference is 9^{t-1} where t = number of towers. This writer does not agree with the proposal to limit calculations to the horizontal plane. In the majority of nighttime patterns the protection is mainly limited to vertical angles. The Commission also proposes to exclude all two and three tower arrays from critical designation. Depending on physical tower placement, tower height and electrical feed parameters such arrays may indeed meet critical array criteria. Such a categorical exclusion should not be considered in this writer's opinion.

The Commission is considering a vast revision of its rules governing AM directional antennas. This writer encourages the use of modern computer analysis which can reduce financial burden on licensees and ensure adequate protection from interference due to elimination of questionable field intensity measurements. It is believed that actual case examples have been provided to support the comments of this writer.

1 Programs MMA, DRIVE, TABLE available from Westberg Consulting, Quincy, Illinois.

2 Early versions of Mininec previously available from Artech House Publishing, Dedham, Massachusetts. Current, improved versions available from EM Scientific, Carson City, Nevada.

3 Program WCAP available from Westberg Consulting, Quincy, Illinois.